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TITLE: COLD TOOL STEEL EXCELLENT IN MACHINABILITY

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INVENTOR-INFORMATION:

NAME

COUNTRY

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ABSTRACT:

PROBLEM TO BE SOLVED: To produce cold tool steel excellent in machinability asannealed at about 90 to 105 HRB and also excellent in machinability even in a hardness region in which hardness after quenching and tempering is about 45 to 55 HRC.

SOLUTION: This cold tool steel excellent in machinability has a composition containing, by weight, 0.3 to 0.6% \underline{C} , 0.2 to 3.0% Si, 0.2 to 3.0% Mn, \leq 4.0% Ni, 1.0 to 4.0% \underline{Cr} , Mo and W alone or in combination so as to satisfy 2Mo+W: 0.2 to 8.0%, 0.05 to 2.0% \underline{V} and 0.050 to 0.4% S, and the balance Fe, in which the total content of carbides is \leq 8%, and the content of fine carbides with the particle size of \leq 0.5 μ m lies in the range of 0.3 to 3%.

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(54) 【発明の名称】 被削性に優れた冷間工具鋼

(57)【要約】

【課題】 本発明は、HRB90~105程度の焼きなましの状態で被削性に優れており、かつ焼入れ焼戻し後の硬さがHRC45~55程度の硬さ領域においても被削性に優れた冷間工具鋼を提供すること。

【解決手段】 重量%で、C:0.3~0.6%、Si:0.2~3.0%、Mn:0.2~3.0%、Ni:4.0%以下、Cr:1.0~4.0%、MoとWを単独または複合で2Mo+W:0.2~8.0%、V:0.05~2.0%及びS:0.050~0.4%を含有し残部がFeであり、かつ炭化物の総量が8%以下、粒径が0.5µm以下の微細な炭化物量が0.3~3%の範囲であるこことを特徴とするとする被削性に優れた冷間工具鋼。

【特許請求の範囲】

【請求項1】 重量%で(以下同じ)、C:0.3~ 0.6%, Si:0.2~3.0%, Mn:0.2~ 3.0%、Ni:4.0%以下、Cr:1.0~4.0 %、MoとWを単独または複合で2Mo+W:0.2~ 8.0%、V:0.05~2.0%及びS:0.050 ~0. 4%を含有し、残部が実質的にFeであり、かつ 炭化物の総量が8%以下、粒径が0.5 μm以下の微細 な炭化物量が0.3~3%の範囲であることを特徴とす る被削性に優れた冷間工具鋼。

【請求項2】 C:0.3~0.6%、Si:0.2~ 3.0%、Mn:0.2~3.0%、Ni:4.0%以 下、Cr:1.0~4.0%、MoとWを単独または複 合で2Mo+W: 0. 2~8. 0%、V: 0. 05~ 2.0%及びS:0.050~0.4%を含有し、更に Nb: 0. $02\sim2$. 0%, Ta: 0. $02\sim2$. 0% 及びTi:0.01~2.0%の1種又は2種以上を含 有し、残部が実質的にFeであり、かつ炭化物の総量が 8%以下、粒径が0.5 mm以下の微細な炭化物量が 0.3~3%の範囲であることを特徴とする被削性に優 20 れた冷間工具鋼。

【請求項3】 C:0.3~0.6%、Si:0.2~ 3.0%、Mn:0.2~3.0%、Ni:4.0%以 下、Cr:1.0~4.0%、MoとWを単独または複 合で2Mo+W: 0.2~8.0%、V: 0.05~ 2. 0%及びS: 0. 050~0. 4%を含有し、更に Ca: 0. 0002~0. 02%, Te: 0. 005~ 0.05%, Pb:0.05~0.50%, Se:0. 02~0.20%及びBi: 0.015~0.15%の 1種又は2種以上を含有し、残部が実質的にFeであ り、かつ炭化物の総量が8%以下、粒径が0.5μm以 下の微細な炭化物量が0.3~3%の範囲であることを 特徴とする被削性に優れた冷間工具鋼。

【請求項4】 C:0.3~0.6%、Si:0.2~ 3.0%、Mn:0.2~3.0%、Ni:4.0%以 下、Cr:1.0~4.0%、MoとWを単独または複 合で2Mo+W: 0.2~8.0%、V: 0.05~ 2.0%及びS:0.050~0.4%を含有し、更に Nb: 0. $02\sim2$. 0%, Ta: 0. $02\sim2$. 0% 及びTi:0.01~2.0%の1種又は2種以上を含 40 いう問題点がある。 有し、またCa: 0.0002~0.02%、Te: $0.005\sim0.05\%$, Pb: $0.05\sim0.50$ %、Se:0.02~0.20%及びBi:0.015 ~0.15%の1種又は2種以上を含有し、残部が実質 的にFeであり、かつ炭化物の総量が8%以下、粒径が 0.5 μm以下の微細な炭化物量が0.3~3%の範囲 であることを特徴とする被削性に優れた冷間工具鋼。 【請求項5】 上記被削性に優れた冷間工具鋼の用途が

HRC45以上の硬さのプレハードン状態で加工するこ

項1~請求項4の何れか1項記載の被削性に優れた冷間 工具鋼。

【発明の詳細な説明】

[0001]

【発明の属する技術分野】本発明は、プレハードン状態 などで使用する被削性に優れた冷間工具鋼に関する。 [0002]

【従来の技術】従来、プレス型などの冷間工具は、JI S SKD11 (C:1. 40~1. 60%, Si: 0.40%以下、Mn:0.6%以下、P:0.030 10 %以下、S:0.030%以下、Cr:11.00~1 3. 00%, Mo: 0. $80\sim1$. 20%, V: 0. 2 0~0.50%、残部がFe)が用いられていた。しか し、このSKD11の鋼は、C含有量が高いため焼なま し硬さが高いので、被削性が悪く、さらにC含有量が高 いため溶接性が悪く、また焼入れ焼戻し後の加工性も悪 い、すなわち硬さを高くするため低温焼戻しをするが、 オーステナイトが多く残存するため、放電加工により割 れが発生するという問題点がある。

【0003】上記SKD11の鋼の欠点を改善した冷間 金型用鋼として、C:0.9~1.3%、Si:0.5 ~2. 0%, Mn: 0. 1~2. 0%, Cr: 5. 0~ 11. 0%, Mo: 1. 3~4. 0%およびV: 0. 1 0~0.35%を含有し、さらに必要に応じてS:0. 20%以下、Pb:0.4%以下、Bi:0.50%以 下およびCa:0.002~0.010%の1種または 2種以上を含有し、残部が実質的にFeからなる冷間ダイ ス鋼 (特公昭64-5100号公報) が知られている。 【0004】この冷間金型用鋼は、高温で焼入れをした 30 後、高温で焼戻しをすることにより、焼入れ時の残留応 力が除去されて組織が安定化するとともに二次硬化硬さ が増大し、硬さ及び靱性が共に優れ、工具としての使用 時のかじりを起こすことがなく、また放電加工などより. 工具に熱が生じる場合にも割れを生ずることがなく工具 寿命が延長され、加工性が大幅に向上されるようになる ものである。しかし、この冷間金型用鋼は、焼なまし後 の被削性が悪く、また焼入れ焼戻し後の硬さ(HRC6 2程度)も高過ぎるため、焼入れ焼戻し後の変形を修正 する加工が困難であるとともに、溶接性も十分でないと

【0005】そこで、本発明者らは、C:0.70~ 0.80%, Si: $0.10\sim0.60\%$, Mn: 0.10~1.00%、Ni:4.0%以下、Cr:6.5 0~7.50%、MoとWを単独または複合で2Mo+ $W: 1.00\sim3.00\%$, $S: 0.03\sim0.40$ %, Ca: 0. 0002~0. 02%, O: 0. 000 2~0.02%を含有し、更に必要に応じてV:0.0 5~3.0%、Nb:0.02~2.0%およびTa: 0.02~2.0%の1種または2種以上を含有し、ま とができるプレハードン用であることを特徴とする請求 50 た必要に応じて $Te:0.01\sim0.06\%$ 、Pb:

0.03~0.10%およびBi:0.02~0.10 %のうちの1種または2種以上を含有し、残部がFeおよび不可避的不純物からなる冷間金型用鋼を発明し、特 許出願した(特願平10-368852号)。

【0006】この冷間金型用鋼は、焼入れ焼戻し後の硬さがHRC56~62程度(焼きなまし硬さがHRB95程度)であるため、多量の製品を冷間加工するための金型などを製造するには適しているが、硬いために機械切削がやや困難であった。少量の製品を冷間加工するための金型などの工具を製造する場合には、これほど高い10硬さは必要がないので、もっと軟らかく被削性のよい冷間工具鋼が求められていた。

[0007]

【発明が解決しようとする課題】本発明は、HRB90~105程度の焼きなましの状態で被削性に優れており、かつ焼入れ焼戻し後の硬さが上記特許出願のものより低いHRC45~55程度の硬さ領域においても被削性に優れた冷間工具鋼を提供することを課題としている。

[8000]

【課題を解決するための手段】上記課題を解決するため、本発明者らは、冷間工具鋼の成分組成、炭化物の量及び大きさなどについて研究していたところ、上記のものよりC含有量を少なくし、かつ炭化物の総量を8%以下にするとともに、粒径が0.5μm以下の微細な炭化物を0.3~3%にすれば、冷間工具鋼の焼きなまし硬さがHRB95~105程度で焼入れ焼戻し後の硬さがHRC45~55程度になるとの知見を得た。本発明は、上記知見に基づいて発明されたものである。

【0009】すなわち、本発明の被削性に優れた冷間工 30 具鋼においては、C:0.3~0.6%、Si:0.2 ~3.0%、Mn:0.2~3.0%、Ni:4.0% 以下、Cr:1.0~4.0%、MoとWを単独または 複合で2Mo+W:0.2~8.0%、V:0.05~ 2.0%及びS:0.050~0.4%を含有し、残部 が実質的にFeであり、かつ炭化物の総量が8%以下、 粒径が0.5μm以下の微細な炭化物量が0.3~3% の範囲にあるものとすることである。

【0010】また、本発明の被削性に優れた冷間工具鋼においては、C:0.3~0.6%、Si:0.2~3.0%、Mn:0.2~3.0%、Ni:4.0%以下、Cr:1.0~4.0%、MoとWを単独または複合で2Mo+W:0.2~8.0%、V:0.05~2.0%及びS:0.050~0.4%を含有し、更に必要に応じてNb:0.02~2.0%、Ta:0.02~2.0%及びTi:0.01~2.0%の1種又は2種以上を含有し、また必要に応じてCa:0.0002~0.02%、Te:0.005~0.05%、Pb:0.05~0.50%、Se:0.02~0.20%及びBi:0.015~0.15%の1種又は2種以

上を含有し、残部が実質的にFeであり、かつ炭化物の 総量が8%以下、粒径が0.5μm以下の微細な炭化物 量が0.3~3%の範囲であるものとすることである。 【0011】また、本発明の被削性に優れた冷間工具鋼 においては、用途がHRC45以上で、好ましくはHR C55以下の硬さのプレハードン状態、すなわち焼入れ 焼戻し状態で加工をすることができるプレハードン用で

あることである。 【0012】

【作用】次に、本発明の被削性に優れた冷間工具鋼の成 分組成及び硬さを上記のように限定した理由を説明す る。

 $C: 0.3 \sim 0.6\%$

Cは、基地の硬さを高めるとともに焼戻しにより二次炭化物を生成して耐摩耗性を確保するために含有させる元素で、0.3%より少ないと必要な硬さを確保することができず、また0.6%より多く含有させると粗大な一次炭化物の生成の原因となって靱性を低下するとともに被削性を低下するので、その含有量を0.3~0.6%20とする。

[0013]Si:0.2~3.0%

Siは、パーライト及びベーナイト焼入れ性を向上し、 焼戻し硬さを増大させるために含有させる元素で、0. 2%より少ないとそれらの効果がなく、3.0%を超え て含有させると靱性が低下するので、その含有量を0. 2~3.0%とする。

 $Mn: 0. 2\sim 3. 0\%$

Mnは、パーライト及びベーナイト焼入れ性を向上し、MnSを生成させるために含有させる元素で、0.2% より少ないとMnSの生成量が少なくなって被削性を向上させることができず、また3.0%を超えて含有させると残留オーステナイト生成の原因となり、朝性も低下するので、その含有範囲を0.2~3.0%する。【0014】Ni:4.0%以下(0%を含まず)

Niは、焼入性を向上させるために含有させる元素で、 4.0%を超えると残留オーステナイトが増加して必要な硬さを確保することが困難となり、また靱性も低下するので、その含有量を4.0%以下とする。

 $Cr: 1. 0\sim 4. 0\%$

40 Crは、焼入れ性を向上させるために含有させる元素で、1.0%より少ないとその効果が小さく、4.0%を超えると高硬度の炭化物が多くなることによって被削性を低下するので、その含有量をCr:1.0~4.0%とする。

を低下するので、その含有量を0.2~8.0%とする。

 $S:0.05\sim0.4\%$

Sは、被削性を向上させるために含有させる元素で、 0.05%より少ないと被削性が改善されず、0.4% を超えると靱性、硬さ及び熱間加工性を低下するので、 その含有量を0.05~0.4%とする。

[0016] V: 0. 05~2. 0%

Vは、高温焼戻し硬さを向上し、結晶粒の粗大化を防止するために含有させる元素で、0.05%より少ないと 10 これらの効果がなく、2.0%を超えると難固溶の一次炭化物が増大して焼入温度を上昇し、靱性及び被削性を低下するので、その含有量を0.05~2.0%とする。

Nb, Ta: 0. 02~2. 0%, Ti: 0. 01~2. 0%

Nb、Ta及びTiは、結晶粒の成長を抑制するために含有せさる元素で、Nb及びTaは0.02%、Tiは、0.1%より少ないと結晶粒の成長抑制効果がなく、2.0%を超えると難固溶の一次炭化物が増大して 20 焼入温度を上昇し、朝性及び被削性を低下するので、その含有量を0.02~2.0%とする。

【0017】Ca:0.0002~0.02% Caは、MnSに固溶し、また酸化物としてMnSの核 となることによりMnSを均一微細に分散させ、靱性の 劣化を抑制するとともに被削性を向上させるために含有 させる元素で、0.0002%より少ないとこの効果が なく、0.02%を超えると靱性が低下するので、その 含有量を0.0002~0.02%とする。

【0018】Te:0.005~0.05% Teは、MnTeを形成して被削性を向上させるために 含有させる元素で、0.005%より少ないとこの効果 がなく、0.05%を超えると和性及び効果加工性が低

がなく、0.05%を超えると**朝性及び**熱間加工性が低下するので、その含有範囲を0.05~0.05%とする。

Pb: 0. 05~0. 50%

Pbは、被削性を向上させるために含有させる元素で、 0.05%より少ないとその効果がなく、0.50%を 超えると熱間衝撃性を低下するので、その含有量を0. 05~0.50%とする。

[0019] Se: 0. 02~0. 20%

Seは、被削性を向上させるために含有させる元素で、 0.01%より少ないとこの効果がなく、0.20%を 超えると朝性を低下するので、その含有量を0.02~ 0.20%とする。

 $Bi: 0.015\sim 0.15\%$

Biは、被削性を向上させるために含有させる元素で、 0.015%より少ないとこの効果がなく、0.15% を超えると靱性を低下するので、その含有量を0.01 ~0.10%とする。 【0020】次に、本発明において炭化物の炭化物の量を限定した理由を説明する。炭化物の総量を8%以下にしたのは、炭化物の総量が8%を超えると被削性が低下するからである。更に粒径が0.5μm以下の微細な炭化物量を0.3%以上にしたのは、0.3%より少ないと焼入れ焼戻し後の硬さがHRC45以上にならないからであり、また3%を超えると被削性が低下するからである。

【0021】また、本発明において、焼入れ焼戻しの熱処理後の硬さをHRC45以上にしているのは、HRC45より低いと金型などの冷間工具に必要な硬さにならないからである。また硬さが高くなり過ぎると金型などの製品にするための機械切削による加工が困難になるので、HRC55以下にするのが好ましい。この硬さにするには、800~100℃に加熱した後空冷し、その後400℃~650℃で空冷することによって達成することができる。

【0022】本発明の被削性に優れた冷間工具鋼は、アレス型、曲げ型、抜き型、絞り型、ダイ、パンチ、転造ダイスなどの従来からある冷間工具鋼の用途と同様に使用することができる。また、本発明の被削性に優れた冷間工具鋼は、アレハードン状態で金型などに機械加工などの加工をして使用することができるし、また焼きなました状態で金型などに機械加工などの加工をし、その後焼入れ焼戻しをし、その後仕上げ加工して使用することもできる。

[0023]

【発明の実施の形態】以下、本発明を実施例によって説明する。

30 【実施例】実施例1

下記表1に示した成分組成の本発明の実施例及び比較例の鋼を高周波誘導炉を用いて通常の方法で溶製し、通常の鋳造方法でインゴットにし、その後通常の加工方法によって鋼材を製造した。これらの実施例及び比較例の鋼材を830℃×3hrの条件で球状化焼きなましをした後硬さ試験片、電解抽出用試験片及び被削性試験片を切取り、これらの試験片を粗加工して粗加工試験片とし、下記表2記載の条件で硬さがHRC45~55になるように焼入れ及び焼戻しをした。これらの試験片のうちの40 硬さ試験片を用いて硬さを測定し、その結果を下記表2に示す。

【0024】また、上記焼入れ及び焼戻しをした電解抽出用試験片及び被削性試験片を精加工して幅10mm×厚さ10mm×長さ10mmの電解抽出用試験片と幅50mm×厚さ40mm×長さ200mmの被削性試験片とし、下記試験方法による炭化物の総量、粒度分布試験及び切削工具寿命を測定し、下記表2に示す。

【0025】炭化物の総量試験

下記電解条件で電解して抽出残渣の重量を測定して炭化 50 物の総量とし、重量%で表した。

電解液: 0.5 N塩酸+クエン酸 、電流密度: 10 m

 A/cm^2

電圧: 0.5V

粒度分布試験

上記抽出残渣をレーザー式散乱分布測定器により粒度分布を測定し、その結果から粒径0.5 μm以下の重量%

を求めた。

【0026】切削工具寿命

下記切削条件で切削を行い、逃げ面摩耗が0.3mmと*

*なるまでの切削長さを測定し、S及びCaを含有しない 材料である比較例No.13 のものを100として指数で表 した。

工具: 超硬エンドミル (UTi20T)、1刃

切削幅: 4. 0mm 切削深さ: 1. 0mm

切削速度: 100m/min 送り: 0.035mm/刃

切削油: 乾式 【0027】

【表1】

(w t %)

3	R.	ı															(w t >	b)
	No.	С	Si	Ma .	Ni	Cr	Мо	T	٧	S	Яb	Ta	Ti	Ca	Te	Pb	Se	Bi
	1	0.4	1.0	1.2	0.04	1.1	L 5	-	0.1	0.20	1	1	-	1	-		-	_
	2	0.6	0.9	2.5	0.06	1.5	0.75	_	0.2	0. 12	0. 1	_		1	1	1	_	_
実	. 3	0.5	0.4	1.8	0.08	2.0	1.2	_	0.4	0. 10	-	0.05	0.1	!	-	1	1	_
	4	0.4	0.8	1.5	0. 05	1.4	2.0	_	1.0	0. 15	-	_	_	0.020	_	0. 2	-	_
_	5	0.5	0.3	L.5	0. 2	1.8	1. 2	_	2.0	0. 10	-	-	_	0.0020	1	1	1	_
推	6	0.3	0.3	1.0	0.08	3.2	4.0	_	0. 3	0.05	0.05	-	1	-	_	-	0.1	-
	7	0.5	0.2	0.7	0. 12	2.5	1.0	1.5	0. 5	0. 10	0.1	_	_	0.0014	-	ı	_	1
háse	8	0. 6	0.5	0.5	4.0	1.0	0.5	3.0	0. 2	0.40	_	0. 1	0.01	_	0.01	_	_	_
例	9	0.5	1.0	0. 2	0, 10	2.2	0.8	5.0	0. 7	0. 08	1	-	1.0	. —		ı	_	0.1
	10	0.4	2.8	0.8	0.08	1.6	0.6	1.0	0.5	0.30	0.5	_	<u> </u>	0.001	0.005		_	_
	11	0.3	0.7	3.0	0.06	20	3.0	2. 0	0. 05	Q 12	-	0.2		_		_	0.1	_
	12	0.6	1.5	20	20	1.0	0. 2	-	1.2	0. 20	<u> </u>	_	0.2	0. 0015	_	_	_	-
	13	0.9	0.3	1.1	_	0.8	_	0.8	1	0. 1	_	_		_	-	_	_	
比	14	1.5	0.3	0.5	_	12.0	1.0	_	0.3	0.003		_	_		_	_		
較	15	0.5	0.3	0.3		5.0	1.5		0.6	0. 007	-	_			_	_	_	
KX	16	1. 2	0.7	2.4	_	2.0	2.0		0.2	0. 2	_	_			<u> </u>	_		_
例	17	1.0	1.0	0.6	_	3.0	0.8	_	0.3	0.08	_	_	_	_			_	_
L	18	0.3	0.3	1.3	_	0.8	0.5			0.05						0.2	<u> </u>	

[0028]

※ ※【表2】

	<u> </u>	2					
abla	No.	据人程度 (C)	発展し温度 (で)	HRC)	炭化物の総量 (別型)	の5g田以下の 民化保証(edd)	が記され
Г	1	900	580	4 5. 3	4.12	1. 73	143
	2	870	500	4 7. 4	7. 2 8	1. 5 2	125
実	3	930	520	5 1. 6	6.59	1. 6 6	181
	4	900	550	5 0. 1	4.32	2.14	136
	5	930	430	5 4 . 8	5.34	1, 26	132
葛	6	970	620	45.7	5.83	2 2 7	121
1	7	870	590	4 7. 2	£ 47	L 05	185
1	8	830	5 5 0	4 8. 3	7. 7 1	0.87	218
Ħ	8	850	530	5 Q B	6.04	0.82	174
	10	870	520	523	4 6 3	Q 75	188
	11	930	540	511	4.58	2.12	145
	12	830	480	5 4. 3	5. 2 8	T 6 9	149
	13	870	450	5 Q 5	10.42	0.97	100
比	14	1030	580	5 2. 1	17.33	1. 36	18
102	15	1030	550	48.0	9.82	4. 2 1	78
*SX	16	970	570	521	12.32	4. 5 T	7.8
例	17	930	550	53.1	8.91	2.59	8 1
	18	850	500	40.2	5.46	0.85	165

切削工具寿命は、比較例配13を100とする指数で表している。

【0029】実施例2

上記実施例1で製造した本発明の実施例及び比較例の鋼 材のうちの球状化焼きなましをしたものの本発明例 No. 1及び No. 6並びに比較例 No. 13及び No. 14から硬 さ試験片、電解抽出用試験片及び被削性試験片を切取 り、これらの試験片を粗加工して粗加工試験片とした。 粗加工をした硬さ試験片を用いて硬さを測定し、その結*

20*果を下記表3に示す。また、上記粗加工をした電解抽出 用試験片及び被削性試験片を上記実施例1のものと同じ 大きさに精加工をし、上記実施例1と同じ方法で上記試 験方法による炭化物の総量、粒度分布試験及び切削工具 寿命を測定し、下記表3に示す。

[0030] 【表3】

\setminus	Ha	使人追皮 (℃)	(プ)	便さ (班別)	英化物の設置 (wtS)	0.5 pm以下の 数化物量(wt%)	切削工具 寿命
英華	1		_	98.3	6. 1 2	·	185
例	6	_	_	9 7. 8	4 6 3		233
比較	13	_	_	9 & 6	- 1 % 77		100
A	M	_	_	98.1	20.66		8 8

表3は、独合なまし状態における硬さ、炭化物の絵画及び切削工具労命を示す。 切削工具寿命は、比較例613を100とする指数で表している。

【0031】これらの結果によると、本発明の実施例の ものは、焼入れ焼戻し後の切削工具寿命が比較例 No. 13 点において異なる。) のものを100として121~2 18であった。また、本発明の実施例のものは、焼きな ましたものの切削工具寿命が比較例 No.13のものを10 0として185と223であった。これに対し、比較例 の焼入れ焼戻し後のものの硬さがHRC 45~55の範 囲のものの切削工具寿命は18~100であった。ま た、比較例のものの焼きなましたものの切削工具寿命が 比較例 No.13のものを100として100と88であっ

【0032】さらに、比較例のものを検討すると、炭化※50

※物の総量が本発明より多い比較例No. 13~17のものは、 いずれも本発明の実施例のものより切削工具寿命が短く (本発明とはVを含有しない点及び炭化物の総量が多い 40 なっている。このうちの比較例No. 15のものは、C含有 量が本発明と同程度であるが、Cr含有量が本発明より 多く、炭化物の総量も本発明より多いので、切削工具寿 命が本発明の実施例のものよりかなり短くなっていた。 また、比較例No. 16のものは、S含有量が0. 2%であ るにもかかわらず、切削工具寿命が本発明の実施例のも のよりかなり低くなっていた。また、比較例No. 18のも のは、Cr 及びV含有量が本発明より少ないので、硬さ が低く、冷間工具鋼に必要な硬さになっていなかった。 [0033]

【発明の効果】本発明の冷間工具鋼は、上記構成にした

1 2

ことにより、400~650℃の温度範囲での焼戻しで、焼入れ焼戻しの硬さをHRC45~55程度にすることができ、また被削性も優れているので、プレハード

ン状態で容易に切削加工をすることができるとともに、 焼きなまし状態では更に容易に切削加工をすることがで きるという優れた効果を奏する。

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CLAIMS

[Claim(s)]

[Claim 1] The C:0.3 - 0.6% (below the same) at weight %, Si:0.2-3.0%, Mn: 0.2-3.0%, less than [nickel:4.0%], Cr:1.0-4.0%, 2 Mo+W:0.2-8.0%, V:0.05 - 2.0%, and S:0.050 - 0.4% are contained for Mo and W by independent or compound. Tool steel between the colds with which the remainder is Fe substantially and the total amount of a brown coal ghost excelled [particle size] in the machinability characterized by being the range whose detailed amount of carbide of 0.5 micrometers or less is 0.3 - 3% 8% or less.

[Claim 2] C:0.3 - 0.6%, Si:0.2-3.0%, Mn:0.2-3.0%, Mo and W by independent or compound less than [nickel:4.0%] and Cr:1.0-4.0% 2 Mo+W:0.2-8.0%, V:0.05 - 2.0% and S:0.050 - 0.4% are contained. Further Nb:0.02-2.0%, Ta: Tool steel between the colds with which one sort (0.02-2.0% and Ti:0.01-2.0%) or two sorts or more are contained, the remainder is Fe substantially, and the total amount of a brown coal ghost excelled [particle size] in the machinability characterized by being the range whose detailed amount of carbide of 0.5 micrometers or less is 0.3 - 3% 8% or less.

[Claim 3] C:0.3 - 0.6%, Si:0.2-3.0%, Mn:0.2-3.0%, Mo and W by independent or compound less than [nickel:4.0%] and Cr:1.0-4.0% 2 Mo+W:0.2-8.0%, V:0.05 - 2.0% and S:0.050 - 0.4% are contained. Further calcium:0.0002-0.02%, One sort (Te:0.005-0.05%, Pb:0.05-0.50%, Se:0.02-0.20%, and Bi:0.015-0.15%) or two sorts or more are contained. Tool steel between the colds with which the remainder is Fe substantially and the total amount of a brown coal ghost excelled [particle size] in the machinability characterized by being the range whose detailed amount of carbide of 0.5 micrometers or less is 0.3 - 3% 8% or less.

[Claim 4] C:0.3 - 0.6%, Si:0.2-3.0%, Mn:0.2-3.0%, Mo and W by independent or compound less than [nickel:4.0%] and Cr:1.0-4.0% 2 Mo+W:0.2-8.0%, V:0.05 - 2.0% and S:0.050 - 0.4% are contained. Further Nb:0.02-2.0%, One sort (Ta:0.02-2.0% and Ti:0.01-2.0%) or two sorts or more are contained. Moreover, calcium:0.0002-0.02%, Te:0.005-0.05%, One sort (Pb:0.05-0.50%, Se:0.02-0.20%, and Bi:0.015-0.15%) or two sorts or more are contained. Tool steel between the colds with which the remainder is Fe substantially and the total amount of a brown coal ghost excelled [particle size] in the machinability characterized by being the range whose detailed amount of carbide of 0.5 micrometers or less is 0.3 - 3% 8% or less.

[Claim 5] Tool steel between the colds excellent in the machinability of claim 1 characterized by the application of the tool steel between the colds excellent in the above-mentioned machinability being an object for pre HADON processible in the state of pre HADON of 45 or more-HRC hardness - claim 4 given in any 1 term.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the tool steel between the colds excellent in the machinability used in the state of pre HADON etc. [0002]

[Description of the Prior Art] Tools between the colds, such as the former and a press die, are JIS. SKD11 (% [C:1.40 - 1.60], less than [Si:0.40%], less than [Mn:0.6%],% [P:0.030 / or less],% [S:0.030 / or less], Cr:11.00-13.00%, Mo:0.80-1.20%,% [V:0.20 - 0.50], and the remainder are Fe) was used. However, machinability is bad, since C content is still higher, weldability is bad, and the workability after hardening annealing is also bad, namely, since this steel of SKD11 has high C content and annealing hardness is high, in order to make hardness high, low-temperature annealing is carried out, but since many austenites remain, there is a trouble that a crack occurs by the electron discharge method.

[0003] As steel for the metal mold between the colds which has improved the fault of the steel of the above SKD11, C:0.9 - 1.3%, Si: 0.5-2.0%, Mn:0.1-2.0%, Cr:5.0-11.0%, Mo:1.3-4.0% and V:0.10 - 0.35% are contained. Furthermore, one sort (less than [Pb:0.4%], less than [Bi:0.50%], and calcium:0.002-0.010%) or two sorts or more are contained S:0.20% or less if needed, and the die steel between the colds (Japanese Patent Publication No. 64-No. 5100 official report) with which the remainder consists of Fe substantially is known.

[0004] After this steel for the metal mold between the colds hardens at an elevated temperature, by annealing at an elevated temperature While the residual stress at the time of hardening is removed and an organization stabilizes, secondary hardening hardness increases. Both hardness and toughness are excellent, also when galling at the time of the use as a tool is not caused and heat arises in a tool from an electron discharge method etc., a crack is not produced, a tool life is extended, and workability comes to improve sharply. However, it has the trouble that weldability is not enough, either while processing which corrects the deformation after hardening annealing is difficult for this steel for the metal mold between the colds, since the machinability after annealing is bad and the hardness (about 62 HRC) after hardening annealing also has it. [too high]

[0005] this invention persons Then, C:0.70 - 0.80%, Si:0.10-0.60%, Mn: 0.10-1.00%, less than [nickel:4.0%], Cr:6.50-7.50%, Mo and W by independent or compound 2 Mo+W:1.00-3.00%, S:0.03 - 0.40%, calcium:0.0002-0.02% and O:0.0002 - 0.02% are contained. Furthermore, one sort (V:0.05 - 3.0%, Nb:0.02-2.0%, and Ta:0.02-2.0%) or two sorts or more are contained if needed. Moreover, 1 of Te:0.01-0.06%, Pb:0.03-0.10%, and Bi:0.02-0.10% of sorts and two sorts or more are contained if needed. The remainder invented and carried out patent application of the steel for the metal mold between the colds which consists of Fe and an unescapable impurity (Japanese Patent Application No. 10-No. 368852).

[0006] Since the hardness after hardening annealing was about (annealing hardness is about 95 HRB) 56 to 62 HRC, it was suitable for manufacturing the metal mold for carrying out cold working of a lot of

products etc., but since it was hard, machine cutting was a little difficult for this steel for the metal mold between the colds. Since such high hardness like this did not have the need when tools, such as metal mold for carrying out cold working of the little product, were manufactured, the softer tool steel between the colds with sufficient machinability was called for. 100071

[Problem(s) to be Solved by the Invention] This invention makes it the technical problem to offer the tool steel between the colds is excellent in machinability with the condition of about 90 to 105-HRB annealing, and the hardness after hardening annealing excelled [tool steel] the thing of the above-mentioned patent application in machinability also in the about 45 to 55-HRC low hardness field. [0008]

[Means for Solving the Problem] While this invention persons lessen C content and make the total amount of a brown coal ghost 8% or less from the above-mentioned thing when it is inquiring about an amount, magnitude, etc. of the component presentation of the tool steel between the colds, and carbide in order to solve the above-mentioned technical problem When particle size made detailed carbide 0.5 micrometers or less 0.3 - 3%, the annealing hardness of the tool steel between the colds acquired knowledge that the hardness after hardening annealing is set to about 45 to 55 HRC by about 95 to 105 HRB. This invention is invented based on the above-mentioned knowledge.

[0009] Namely, it sets to the tool steel between the colds excellent in the machinability of this invention. C:0.3 - 0.6%, Si:0.2-3.0%, Mn:0.2-3.0%, Mo and W by independent or compound less than [nickel:4.0%] and Cr:1.0-4.0% 2 Mo+W:0.2-8.0%, V:0.05 - 2.0% and S:0.050 - 0.4% are contained, the remainder is Fe substantially, and the total amount of a brown coal ghost is that the detailed amount of carbide of 0.5 micrometers or less shall have particle size in the range which is 0.3 - 3% 8% or less. [0010] Moreover, it sets to the tool steel between the colds excellent in the machinability of this invention. C:0.3 - 0.6%, Si:0.2-3.0%, Mn:0.2-3.0%, Mo and W by independent or compound less than [nickel:4.0%] and Cr:1.0-4.0% 2 Mo+W:0.2-8.0%, V:0.05 - 2.0% and S:0.050 - 0.4% are contained, and the need is accepted further. Nb:0.02-2.0%, One sort (Ta:0.02-2.0% and Ti:0.01-2.0%) or two sorts or more are contained. The need is accepted. Moreover, calcium:0.0002-0.02%, Te:0.005-0.05%, One sort (Pb:0.05-0.50%, Se:0.02-0.20%, and Bi:0.015-0.15%) or two sorts or more are contained. The remainder is Fe substantially and the total amount of a brown coal ghost is that particle size shall be the range whose detailed amount of carbide of 0.5 micrometers or less is 0.3 - 3% 8% or less.

[0011] Moreover, are 45 or more HRC(s) and an application is in the pre HADON condition for pre

[0011] Moreover, are 45 or more HRC(s) and an application is in the pre HADON condition for pre HADON of 55 or less-HRC hardness, i.e., the object which can process it in the state of hardening annealing, preferably in the tool steel between the colds excellent in the machinability of this invention. [0012]

[Function] Next, the reason which limited a component presentation and hardness of the tool steel between the colds excellent in the machinability of this invention as mentioned above is explained. Since machinability is fallen while are the element made to contain in order for annealing to generate secondary carbide and to secure abrasion resistance, while C raises the hardness of a base C:0.3 to 0.6%, required hardness is not securable if fewer than 0.3%, and it will become the cause of generation of big and rough primary carbide if it is made to contain mostly from 0.6%, and falling toughness, the content is made into 0.3 - 0.6%.

[0013] Si: Si improves a pearlite and bainite hardenability 0.2 to 3.0%, it is the element made to contain in order to increase tempering hardness, when fewer than 0.2%, those effectiveness does not exist, and since toughness will fall if it is made to contain exceeding 3.0%, make the content into 0.2 - 3.0%. Mn: Since it will become the cause of retained austenite generation and toughness will also fall if Mn improves a pearlite and bainite hardenability 0.2 to 3.0%, it is the element made to contain in order to make MnS generate, the amount of generation of MnS can decrease and machinability cannot be raised, if fewer than 0.2%, and it is made to contain exceeding 3.0%, carry out the content range 0.2 to 3.0%. [0014] nickel: Less than [4.0%] (0% is not included)

Since it is the element made to contain in order to raise hardenability, it will become difficult for retained austenite to increase and to secure required hardness if it exceeds 4.0%, and toughness also

falls, nickel makes the content 4.0% or less.

Cr: 1.0-4.0%Cr is the element made to contain in order to raise hardenability, and since it will fall machinability when the carbide of a high degree of hardness increases in number if the effectiveness is small when there is than 1.0%, and it exceeds 4.0%, it makes the content Cr:1.0-4.0%. [less] [0015] 2Mo+W: -- since it is the element made to contain in order for Mo and W to improve bainite-hardening nature and to make tempering hardness high 0.2 to 8.0%, the primary carbide of difficulty dissolution will increase, hardening temperature will be gone up, if the 2nd order cannot be stiffened by raising bainite-hardening nature and annealing if fewer than 0.2%, and it exceeds 8.0%, and toughness is fallen, the content is made into 0.2 - 8.0%.

It is the element made to contain in order to raise machinability, if fewer than 0.05%, machinability will not be improved, but since S:0.05 - 0.4%S will fall toughness, hardness, and hot-working nature if it exceeds 0.4%, it makes the content 0.05 - 0.4%.

[0016] Since artificial tempering is carried out and hardness is improved, are the element made to contain in order to prevent big and rough-ization of crystal grain, such effectiveness does not exist when fewer than 0.05%, the primary carbide of difficulty dissolution will increase if it exceeds 2.0%, and V:0.05 - 2.0%V goes up hardening temperature and falls toughness and machinability, it makes the content 0.05 - 2.0%.

In order that Nb, and Ta and Ti may control grain growth Ti:0.01 to 2.0% Nb and Ta:0.02-2.0%, it is a content ****** element, and 0.02%, since there is no grain growth depressor effect when fewer than 0.1%, the primary carbide of difficulty dissolution will increase if it exceeds 2.0%, hardening temperature is gone up and Nb and Ta fall toughness and machinability, Ti makes the content 0.02 - 2.0%.

[0017] calcium: It is the element made to contain in order to raise machinability, while distributing MnS uniformly minutely and controlling degradation of toughness by calcium's dissolving to MnS 0.0002 to 0.02%, and becoming the nucleus of MnS as an oxide, when fewer than 0.0002%, this effectiveness does not exist, and since toughness will fall if it exceeds 0.02%, make that content into 0.0002 - 0.02%. [0018] Te: It is the element made to contain in order for Te to form MnTe 0.005 to 0.05% and to raise machinability, when fewer than 0.005%, this effectiveness does not exist, and since toughness and hotworking nature will fall if it exceeds 0.05%, make that content range into 0.05 - 0.05%.

Pb: 0.05-0.50%Pb is the element made to contain in order to raise machinability, when there is than 0.05%, it does not have the effectiveness, and since it will fall the impact nature between heat if it exceeds 0.50%, it makes the content 0.05 - 0.50%. [less]

[0019] Se: It is the element made to contain in order that Se may raise machinability 0.02 to 0.20%, when fewer than 0.01%, this effectiveness does not exist, and since toughness will be fallen if it exceeds 0.20%, make that content into 0.02 - 0.20%.

Bi: 0.015-0.15%Bi is the element made to contain in order to raise machinability, when there is than 0.015%, it does not have this effectiveness, and since it will fall toughness if it exceeds 0.15%, it makes that content 0.01 - 0.10%. [less]

[0020] Next, the reason which limited the amount of the carbide of carbide in this invention is explained. The total amount of carbide was made 8% or less because machinability would fall, if the total amount of carbide exceeded 8%. Furthermore, it is because the hardness after hardening annealing will not be set to 45 or more HRC(s) if there is that particle size made [less] the detailed amount of carbide of 0.5 micrometers or less 0.3% or more than 0.3%, and is because machinability will fall if it exceeds 3%.

[0021] Moreover, in this invention, it is because it will not become hardness required for tools between the colds, such as metal mold, if it is lower than HRC45 to set temper of hardening annealing to 45 or more HRC(s). Moreover, since processing by machine cutting for making it products, such as metal mold, will become difficult if hardness becomes high too much, it is desirable to make it 55 or less HRC. In order to make it this hardness, it can attain by carrying out air cooling, after heating at 800-1000 degrees C, and carrying out air cooling at 400 degrees C - 650 degrees C after that. [0022] The tool steel between the colds excellent in the machinability of this invention can be used like

the application of the tool steel between a certain colds from the former, such as a press die, a bending die, a cutting die, a drawing die, a die, punch, and rolled dies. Moreover, the tool steel between the colds excellent in the machinability of this invention processes machining etc. into metal mold etc. in the condition of could use machining etc. for metal mold etc. in the state of pre HADON, having processed it into it, and having annealed, and carries out hardening annealing after that, and it can also be used for it, finish-machining it after that.

[Embodiment of the Invention] Hereafter, an example explains this invention.

[Example] The steel of the example of this invention of the component presentation shown in the example 1 following table 1 and the example of a comparison was ingoted by the usual approach using the high frequency induction furnace, it was made the ingot by the usual casting approach, and steel materials were manufactured by the after that usual processing approach. After carrying out balling-up annealing for the steel materials of these examples and the example of a comparison on condition that 830 degree-Cx3hr, the piece of a hardness test, the test piece for electrolytic extraction, and the machinability test piece were cut off, these test pieces were roughed and it considered as the roughing test piece, and hardening and annealing were carried out so that hardness might be set to HRC 45-55 on condition that the following table 2 publication. Hardness is measured using the piece of a hardness test of these test pieces, and the result is shown in the following table 2.

[0024] Moreover, energy processing of the test piece for electrolytic extraction and machinability test piece which carried out the above-mentioned hardening and annealing is carried out, it considers as the test piece for electrolytic extraction with a 10mm[in width-of-face / of 10mm / x thickness] x die length of 10mm, and a machinability test piece with a 40mm[in width-of-face / of 50mm / x thickness] x die length of 200mm, the total amount of the carbide by the following test method, a particle-size-distribution trial, and a cutting-tool life are measured, and it is shown in the following table 2. [0025] It electrolyzed by the total amount trial following electrolytic condition of carbide, the weight of extract residue was measured, and it considered as the total amount of carbide, and expressed with weight %.

electrolytic-solution: -- 0.5-N hydrochloric-acid + citric acid current density: -- 10mA[/cm] 2 electrical-potential-difference: -- particle size distribution were measured for the 0.5V particle-size-distribution test above-mentioned extract residue with the laser type dispersion distribution measuring instrument, and it asked for weight % with a particle size of 0.5 micrometers or less from the result. [0026] Example No.of comparison 13 which are the ingredient which cuts by the cutting-tool life following cutting conditions, measures the cutting die length until flank wear is set to 0.3mm, and does not contain S and calcium It expressed with the characteristic, having used the thing as 100. tool: -- a superhard end mill (UTi20T) and 1 cutting-edge width-of-cut:4.0mm cutting depth: -- 1.0mm cutting speed: -- 100 m/min Delivery: [0.035mm / cutting-edge cutting oil: -- dry type -- 0027] [Table 1]

Ź	Ę	1						_									(w t ?	<u>6)</u>
	No.	C	Si	Mn	Ni	Cr	Мo	W	V	S	Nb	Ta	Ti	Ca	Te	Pb	Se	Bi
	1	0.4	1.0	1.2	0.04	1.1	1.5		0.1	0.20	1		-		_			
	2	0.6	0. 9	2. 5	0.06	1.5	0.75		0.2	0.12	0. 1							
実	3	0.5	0.4	1.8	0.08	2. 0	1. 2	_	0.4	0.10	_	0.05	0. 1		_		-	_
	4	0.4	0.8	1.5	0.05	1.4	2.0	_	1.0	0.15				0.020		0. 2		
	5	0.5	0.3	1.5	0. 2	1.8	1. 2	_	2. 0	0.10		<u> </u>	_	0.0020				
施	6	0.3	0.3	1.0	0.08	3. 2	4.0		0. 3	0.05	0. 05						0.1	_
	7	0.5	0. 2	0.7	0.12	2.5	1.0	1.5	0. 5	0. 10	0.1			0.0014		_		
MI	8	0.6	0.5	0.5	4. 0	1.0	0.5	3. 0	0. 2	0.40		0.1	0.01		0.01	_		
例	9	0.5	1.0	0. 2	0.10	2. 2	0.8	5. 0	0. 7	0. 08	_	_	1.0					0.1
	10	0.4	2.8	0.8	0.08	1.6	0.6	1. 0	0.5	0. 30	0.5	_		0.001	0.005			
	11	0.3	0.7	3.0	0.06	2.0	3.0	2. 0	0. 05	0.12		0.2	_				0.1	
	12	0.6	1. 5	2.0	2. 0	1.0	0. 2	•	1.2	0, 20	_		0.2	0. 0015	_			
	13	0.9	0.3	1.1		0.8		0.8		0.1				_				
比	14	1.5	0.3	0.5	—	12.0	1.0		0.3	0, 003	<u> </u>	_						
	15	0.5	0.3	0. 3	_	5.0	1.5	-	0.6	0. 007	<u> </u>	<u> </u>						_
較	16	1.2	0.7	2. 4		2.0	2. 0		0.2	0. 2								
例	17	1.0	1.0	0.6	<u> </u>	3. 0	0.8		0.3	0.08	_	_					_	
	1.B	0.3	0.3	1. 3		0, 8	0.5		-	0.05	_				-	0.2		

[0028] [Table 2]

1	Nic.	焼入温度 (C)	焼戻し温度	er è	炭化物の総量 (wt K)	0.5 μm以下の 炭化物量(wis)	切削工具 参
	1	900	580	4 5. 3	4. 1 2	1. 73	143
	2	870	500	4 7. 4	7. 28	1. 5 2	1 2 5
実	9	930	520	5 1. 6	6. 5 9	1. 6 6	161
	4	900	550	5 0. 1	4. 3 2	2. 14	136
	5	930	430	5 4. 8	5. 3 4	1. 2 6	1 3 2
施	6	970	620	4 5. 7	5. 8 3	2. 2 7	121
	7	870	590	4 7. 2	6. 4 7	1. 0 5	165
	8	830	550	4 8. 3	7. 7 1	0. 8 7	218
例	8	850	5 3 0	5 O. B	6. 0 4	0. 8 2	174
	10	870	520	5 2. 3	4. 6 3	0.75	188
	11	930	540	5 3. 1	4. 5 8	2. 1 2	1 4 5
	12	830	4 B O	5 4. 3	5. 2 8	0. 6 9	149
	13	870	450	5 0. 5	1 0. 4 2	0. 9 7	100
比	14	1030	580	5 2. 1	1 7. 3 3	1. 3 6	18
	15	1030	5 5 0	4 8. 0	9.82	4. 2 1	78
較	16	970	5 7 0	5 2. 1	1 2. 3 2	4. 5 7	7.8
例	17	930	550	5 3. l	8. 9 1	2. 5 9	8 1
	18	850	500	4 0. 2	5.46	0. 8 5	165

切削工具寿命は、比較例約13を100とする指数で表している。

[0029] Although balling-up annealing of the steel materials of the example of this invention manufactured in the example 2 above-mentioned example 1 and the example of a comparison was carried out, it is an example of this invention. It reaches No.1. It is an example of a comparison to No.6

list. It reaches No.13. The piece of a hardness test, the test piece for electrolytic extraction, and the machinability test piece were cut out from No.14, these test pieces were roughed, and it considered as the roughing test piece. Hardness is measured using the piece of a hardness test which roughed, and the result is shown in the following table 3. Moreover, energy processing is carried out for the test piece for electrolytic extraction and machinability test piece which carried out the above-mentioned roughing to the same magnitude as the thing of the above-mentioned example 1, the total amount of the carbide by the above-mentioned test method, a particle-size-distribution trial, and a cutting-tool life are measured by the same approach as the above-mentioned example 1, and it is shown in the following table 3. [0030]

[Table 3]

\setminus	Ha.	焼入温度 (℃)	焼戻し温度 (℃)	硬さ (HJRB)	炭化物の総量 (wtが)	0.5 μm以下の 炭化物量(wt%)	切削工具 好命
実	1			9 8. 3	6. 12	<u> </u>	185
施例	6			9 7. 8	4.63		233
比	13			9 & 6	13.77		100
較例	14		_	99.1	20.66		8.8

表 3 は、焼きなまし状態における硬さ、炭化物の総量及び切削工具寿命を示す。 切削工具寿命は、比較例kb.13を100とする指数で表している。

[0031] According to these results, for the thing of the example of this invention, the cutting-tool life after hardening annealing is an example of a comparison. It was 121-218, having used as 100 the thing of No.13 (in the point which does not contain V, and a point with many total amounts of carbide, it differs from this invention.). Moreover, for the thing of the example of this invention, although annealed, a cutting-tool life is an example of a comparison. It was 185 and 223, having used the thing of No.13 as 100. On the other hand, the hardness of the thing after hardening annealing of the example of a comparison of the cutting-tool life of the thing of the range of HRC 45-55 was 18-100. moreover, the thing of the example of a comparison -- having annealed -- although -- a cutting-tool life -- example of a comparison It was 100 and 88, having used the thing of No.13 as 100.

[0032] Furthermore, if the thing of the example of a comparison is examined, as for each of things of example No.of comparison 13-17 which have more total amounts of carbide than this invention, the cutting-tool life is short from the thing of the example of this invention. Although the thing of example No.of comparison 15 of these had C content comparable as this invention, since there were more Cr contents than this invention and the total amount of carbide also had them than this invention, the cutting-tool life became in the thing twist of the example of this invention, and was short. [more] Moreover, the cutting-tool life became in the thing twist of the example of this invention, and the thing of example No.of comparison 16 was low, although S content was 0.2%. Moreover, the thing of example No.of comparison 18 is Cr. And since there were few V contents than this invention, hardness was low and had not turned into hardness required for the tool steel between the colds.

[Effect of the Invention] It does so the outstanding effectiveness that cutting can be carried out still more easily, in annealed condition while it can carry out cutting easily in the state of pre HADON, since the tool steel between the colds of this invention can set hardness of hardening annealing to about 45 to 55 HRC and machinability is also excellent in annealing in a 400-650-degree C temperature requirement by having made it the above-mentioned configuration.

[Translation done.]